

## Effect of Environmental Thinking through Architectural Design Studio Education

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### Abstract:

Complaints about the poor performance of architects and the declining quality of buildings have been widespread and were blamed not only on the architects but on what was thought to be the poor quality of architectural education. This paper explores the benefits of integrating comprehension of environmental studies in architecture pedagogy. This was accomplished through Environmental control core course offered for last year architecture level. A project was conducted with students in Architecture Department, Tanta University. A problematic of design entitled designing an environmental friendly restaurant in three different sites in Egypt, was given to students. First, students begin their project by site's environmental conditions data collection collected from the literature and from observations in studio practices. Then they begin their analysis using environmental software. At the second stage, students are expected to develop their designs through selecting environmental treatments in accordance with environmental comprehension and data for each site. In last stage, evaluation of environmental efficiency of suggested projects and their rational forms' development, which were the main targets of this study, were investigated. Best environmental treatment and energy saving were the main assessment aspects. Also, students compare forms created with their studied process. As a result of the following course, students were trained to thoroughly transform their architectural projects forms with respect to environmental conditions and energy saving. Finally the paper use these finding to assure the need of environmental control course as a powerful tool of learning in architecture education and comprehensive approach that illustrate the relation between design and environmental studies to enhance the performance of architects and the quality of building design .

### 1. Introduction

A good architecture should reflect the life of the community in which it is located. Therefore architectural education is a multi-faceted field due to the complexity of the social and cultural aspect normally associated to it. Architectural education is not restricted to physical building design and also incorporates value system, philosophy, sustainability, technologies and other related areas. Diverse subjects other than Design Studio offered in any architecture courses reflect the complexities integral in architecture. Integration of these diverse subjects with the Design Studio is very important as the architecture course offered should be able to produce innovative, creative and holistic architects who are sensitive to the needs of the society, the environment and technology. <sup>3</sup>As a result of UIA/UNESCO charter of Architecture education<sup>4</sup>, international institutions and third world nations recognize the need for the reorientation of architectural design education toward an engaging policy that considers community service as a priority task. With a policy that aims to improve the learning and teaching methods for architectural design, our department (the Department of Architecture , Tanta University) has developed an environmental control course, in which design method development and reflection are key research areas. In implementing this course, the present study serves as an introductory effort to guide future empirical research.

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<sup>3</sup> Ibrahim, N. L. N., & Utaberta, N. (2012). Learning in architecture design studio. *Procedia-Social and Behavioral Sciences*, 60, 30-35. <http://www.sciencedirect.com/science/article/pii/S1877042812037974>

<sup>4</sup> Charter For Architectural Education', UIA/UNESCO, 1996 [[www.unesco.org/most/uiachart.htm](http://www.unesco.org/most/uiachart.htm)]

However, the aim of this study is to develop and to establish a theoretical formulation that describes the design process of architects based on environmental studies. This study uses data collected from the literature and from observations in studio practices. In addition, the study relies on the studio teaching and design experience of the author. Data analysis is based on the comparison of the knowledge from the literature with the empirical knowledge gained from teaching in the studio, a considerable part of which is practically inspired by ideas generated through discussions with students and instructors.

As many other disciplines, the movement from modernism to post-modernism has profoundly affected the approach to architectural design. While the modernist movement has encouraged the perception of the designer as supreme creator, making decisions based primarily on aesthetic, financial, theoretical, and political concerns, the move to postmodernism has placed a greater emphasis on issues, such as social responsibility, sustainability, environmental responsiveness, environmental integrity and human health.<sup>5</sup> Architectural students' lack of attention towards the environment in which they design their buildings is a long standing problem and a recurrent issue in debates on teaching architecture.<sup>6</sup>

Complaints about the poor performance of architects and the declining quality of buildings have been common in the west since the Renaissance. They intensify at the end of the eighteenth century, when architectural education became institutionalized. The failures were blamed not only on the architects but on what was thought to be the poor quality of architectural education.

## **2. Methodology**

### **1. Context analysis**

The Environmental design project entitled Designing an environmental friendly restaurant in three different sites in Egypt, was presented to Final year of architecture. The integration of various passive architectural strategies was the focal point. Also energy saving was the second prior in project design. Course professors taught weekly lectures to provide students with theoretical concepts for environmental design process. Students begin their project by environmental conditions data collection and analysis of different sites using climate consultant program.

### **2. Design support tools**

At the second stage, the selection process and the development of the architecture design form were based on environmental conditions analysis. Students applied passive architecture strategies according to thermal comfort zone, solar path, wind rose, relative humidity and other environmental parameters. The previous environmental knowledge gained and analyzed in the first stage, are Condensed into useful form that can lead to the formulation of design criteria, identification of patterns of spatial arrangement, and development of initial design theory. Design spatial arrangement at this stage is supported by environmental studies.

## **Experimental procedure**

Design builder program was the main tool to analysis and develop three chosen projects in three different sites completed during the course in Spring semester. The evaluation framework considered environmental building design efficiency and energy saving. Also, written analysis and graphic materials produced by the students for their final presentations were also assessed. Also, students conducted analysis to justify their rational created final forms within their work process.

## **3. Project Design Processes**

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<sup>5</sup> Milburn, L. A. S., & Brown, R. D. (2003). The relationship between research and design in landscape architecture. *Landscape and urban planning*, 64(1), 47-66.

<sup>6</sup> François, A., Nussaume, Y., & Szanto, C. (2012, May). Teaching Environmental Issues in an Architectural Design Studio. Description and Students' Response. In *Proceedings of the 5th WSEAS International Conference on Landscape Architecture (LA'12)*, University of Algarve, Faro, Portugal (pp. 2-4).

Architectural design is a process that is performed in order to meet requirements of the location where the structure will be built with the current environmental data based on form, function and construction. It's well known that, architectural design is a problem solving process which has the purpose of reaching a synthesis through analytic approaches, involving activities which try to find out appropriate combinations of physical (location, topography, pattern, climate, etc.), cultural (social, economical, political, historical, aesthetics, etc.) and technological (science, technology, etc.) components, for creating functional – sustainable built – environment .All these features make definition of target design solution harder and reveals the complexity of reality as a process that requires creativity.<sup>7</sup> In general, we could describe the design activity as a process based on positive theory and implemented through rational thinking and creative skill.<sup>8</sup>

### 3. The rational phase

First design phase involves the study of the literature which aids the designer in arriving at knowledge through reasoning or analysis. This kind of research aims to gain knowledge about space requirements and characteristics and seeks knowledge in two areas: (a) space determinants, including the values and needs of the users and the community at large. This knowledge concerns the functions or services that the proposed design provides, as well as the related space requirements and their characteristics. (b) Space arrangement, circulation flows, and adjacency relationships. In this area, a research is conducted to explore published designs and identify patterns of space arrangement. REF Spatial organization has a strong relationship with the determination of values, needs, and activities. Knowledge obtained in (a) and (b) are then analyzed and condensed into a short but useful form that can lead to the formulation of design criteria, identification of patterns of spatial arrangement, and development of initial design theory. However, design theory at this stage is considered preliminary and needs supporting evidence through comparison with environmental studies of the site obtained from Climate consultant program. The purpose of Climate Consultant is not simply to plot climate data, but rather to organize and represent this information in easy-to-understand new ways that reveals the subtle attributes of the climate and its impact on built form. The goal is to help users create more energy efficient, more sustainable buildings, each of which is uniquely designed for its particular spot on our planet. The basic plots are the usual temperature, radiation, and humidity bar graphs, while beyond these are more sophisticated graphic analysis options.

### The creative phase

The student starts then to verify and develop obtained form according to space theories with the environmental conditions determinants to generate new conceptual solutions with architectural passive strategies. In the creative design phase, the designer can contribute to reducing or increasing thermal load through developing previous building form to adapt with surrounding site aspects. The most important applied design strategies were the following: 1) Form reshape and formation. 2) Building orientation and ventilation to attract or reduce wind. 3) Design of the wall, roof and windows section to control the internal environment. 4) Shading designs and natural lighting. 5) Finishing materials. 6) Natural and mechanical cooling and heating systems. They are expected to integrate their preceding experience and analysis of the site into their design; to think about and express in their building the relationship between architecture and environment.

### 4. Students' work and project presentation:

As cited in the methodology, first students collect environmental data of each city and analyze it at climate consultant. Wind rose, Sun Path, Dry bulb and comfort curve were assessed for each city. A simulation on design builder was then proceeded to investigate the theoretical primary form performance with the analyzed data to develop the form and reach the ideal adapted design. Also, design strategies revealed from psychometric chart at climate consultant directed the choice of architecture treatments such as sun breakers or using wind catcher or double wall, etc. Theses architecture treatments are also examined by design builder to figure out the efficiency of suggested treatment and how to develop it to deliver comfortable environmental needs and to reduce energy required to active design means.

<sup>7</sup> Uzunoglu, S. S., & Uzunoglu, K. (2011). The application of formal perception of gestalt in architectural education. *Procedia-Social and Behavioral Sciences*, 28, 993-1003.  
<http://www.sciencedirect.com/science/article/pii/S1877042811026231>

<sup>8</sup> Cross, N. (2007). From a design science to a design discipline: Understanding designerly ways of knowing and thinking. *Design research now*, 41-54.. <http://viola.informatik.unibremen.de/typo/fileadmin/media/lernen/Turing-05CrossDesign.pdf>

#### 4.1 First Project:

Designing an environmental friendly restaurant in hurghada city, Red Sea, Egypt

##### 4.1.1 Environmental data:

- **Wind rose at Hurghada:**

It is obvious, from the wind rose at the selected location of the first project of Hurghada city during the year , figure (1), that the desired winds to achieve moderate temperature from 20 to 24 degrees Celsius have direction from the west. This prevailing wind also has the longest period of wind blowing. For that reason Students had to use the western wind direction in order to capture the desired wind and change the building form consequently.

- **Sun Path at Hurghada:**

The solar path, figure (1), shows that the solar radiation with an angle higher than 60 is undesirable hot radiation. Also, the vertical radiation on the eastern and western façades is undesirable. The radiation on the southern façade at an angle of less than 60 degrees is a desirable moderate radiation. As a result to the previous sun path study , solar breakers had to be designed to allow the desired rays to enter the building and prevent undesirable rays.

- **Dry bulb temperature at Hurghada:**

The three-dimensional curve of the temperature of the dry thermometer, figure (1), shows that the temperature in September, June and July is high and undesirable as the temperature curve shows throughout days' hours. It should be avoided with treated strategies.

- **Comfort Curve at Hurghada:**

The thermal comfort curve, figure (1), shows the number of comfortable hours and design policies proposed to achieve thermal comfort for the rest of the time through the year. The recommendations were as follows:

- a. Solar breakers for windows modify 2615 uncomfortable hours to comfortable hours.
- b. Indirect cooling of radiation that change 2841 uncomfortable hours to comfortable hours.
- c. Direct cooling by evaporating that change 2165 uncomfortable hours to comfortable hours.
- d. Preserve the internal temperature of uncomfortable 1886 hours to comfortable hours.

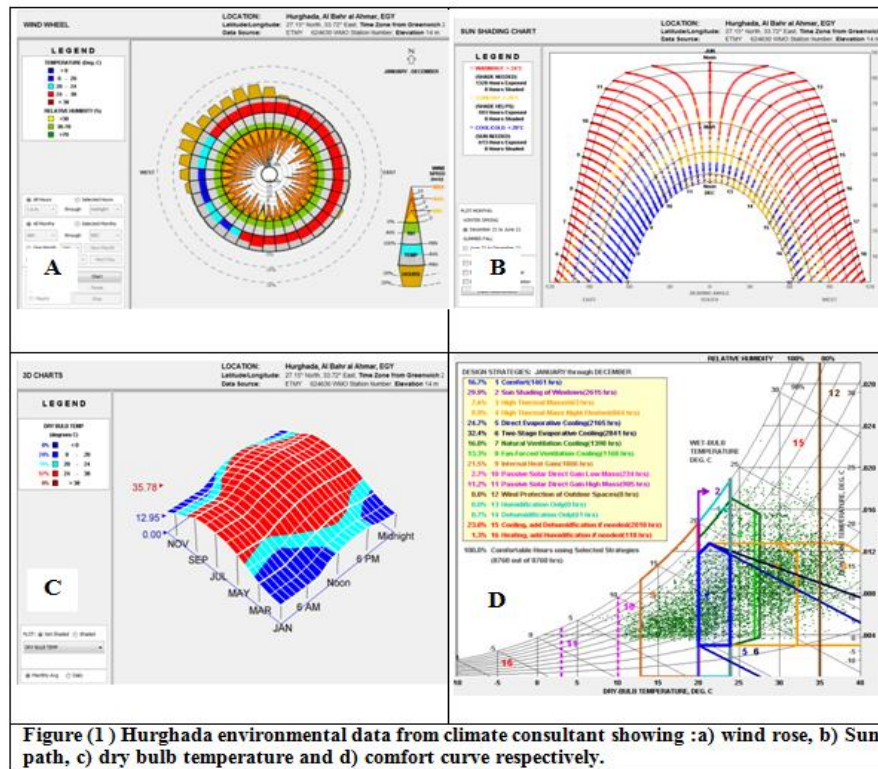


Figure (1) Hurghada environmental data from climate consultant showing : a) wind rose, b) Sun path, c) dry bulb temperature and d) comfort curve respectively.

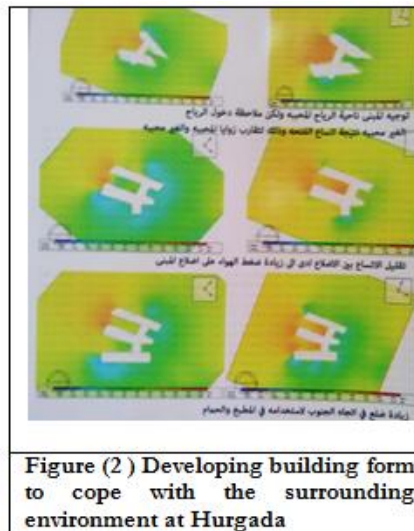


Figure (2) Developing building form to cope with the surrounding environment at Hurgada

#### 4.1.2 Developing Form according to environment

As a result of the previous environmental parameters the form accomplished by theories for used spaces from the program were adapted in shape to cope with the surrounding environment, , figure (2).

#### 4.1.3 Environmental design strategies

Trough analyzing data collected and developing form according to environmental parameters students used the following environmental beneficial design strategies, , figure (3):

Students consider building form and increase of external wall thickness to enhance thermal performance of the building envelope and isolate heat internally.

- Students used evaporative cooling of air to add benefit of conditioning the air with more moisture for the comfort of building occupants.

- Also Double roof was used to minimize solar gain and heat storage. Also, to provide under roof ventilation and environmental shading.
- Using Green roofs to cool and humidify the surrounding air creating microclimate to benefit the surrounding area.

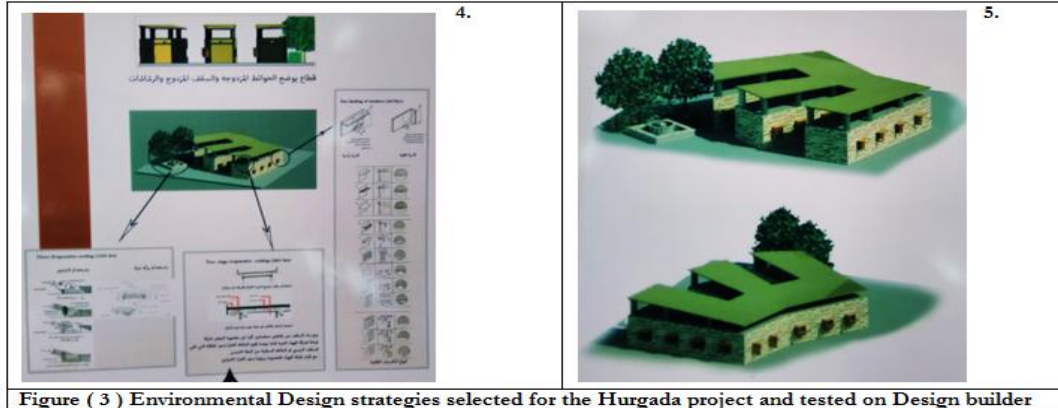
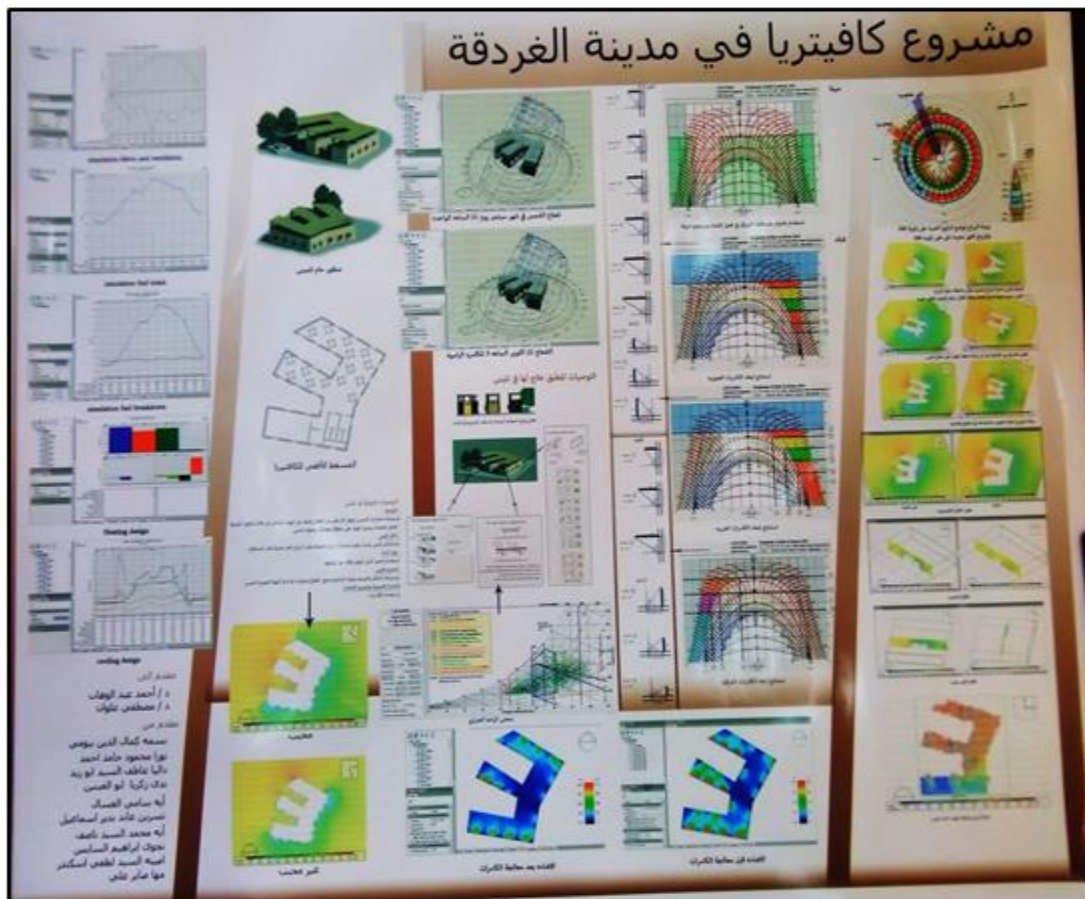


Figure ( 3 ) Environmental Design strategies selected for the Hurgada project and tested on Design builder

#### 4.1.4 Students' presentation

- Students presented their project, , figure (4), on printed colored banners and a jury was carried to verify their complete understanding of the design process according to environmental parameters.



**Figure (4) Student's presentation of their project on environmentally friendly restaurant in hurghada city, Red Sea, Egypt**

**4. 2 Second Project:**

Designing an environmental friendly restaurant in Al Ismailia,, Egypt

**4.2.1 Environmental data:**

• **Wind rose at Al Ismailia:**

It is clear from the analysis of the wind rose, figure (5), at the site chosen for the second project in the city of Ismailia throughout the year that the desired winds with moderate temperature from 20 to 24 degrees Celsius direction were from the west and north. There were unwanted cold wind coming from the south-west direction and must be avoided. Students had to take advantage of the western and northern direction to catch the desired wind. Also they had to disperse the unwanted wind coming from the southwest direction by changing the building form accordingly.

• **Sun Path at Al Ismailia:**

The solar path, figure (5), shows that the solar radiation with an angle higher than 70 is undesirable hot radiation. Also, the vertical radiation on the western façade was avoidable radiation. Radiation on the southern façade at an angle of less than 70 degrees is a desirable moderate radiation. Therefore it is necessary to design solar breakers to allow the desired rays to access the building and prevent unwanted rays.

• **Dry bulb temperature at Al Ismailia:**

The three-dimensional curve of the temperature of the dry thermometer, figure (5), shows that the temperature in September and July is high and undesirable and should be avoided and treated. Also the curve shows temperature throughout the day.

• **Comfort Curve at Al Ismailia:**

The thermal comfort curve, figure (5), shows the number of comfortable hours and design policies proposed to achieve thermal comfort for the rest of the time. Recommendations obtained from the curve were as follow:

- a) Use of the solar breakers for windows change 1967 uncomfortable hours into comfortable hours.
- b) Use of fans modify 1681 uncomfortable hours to comfortable hours.
- c) Maximize the use of natural ventilation to modify 1655 uncomfortable hours to comfortable hours.
- d) Maximize the use of solar radiation to modify 1174 uncomfortable hours to convenient hours.

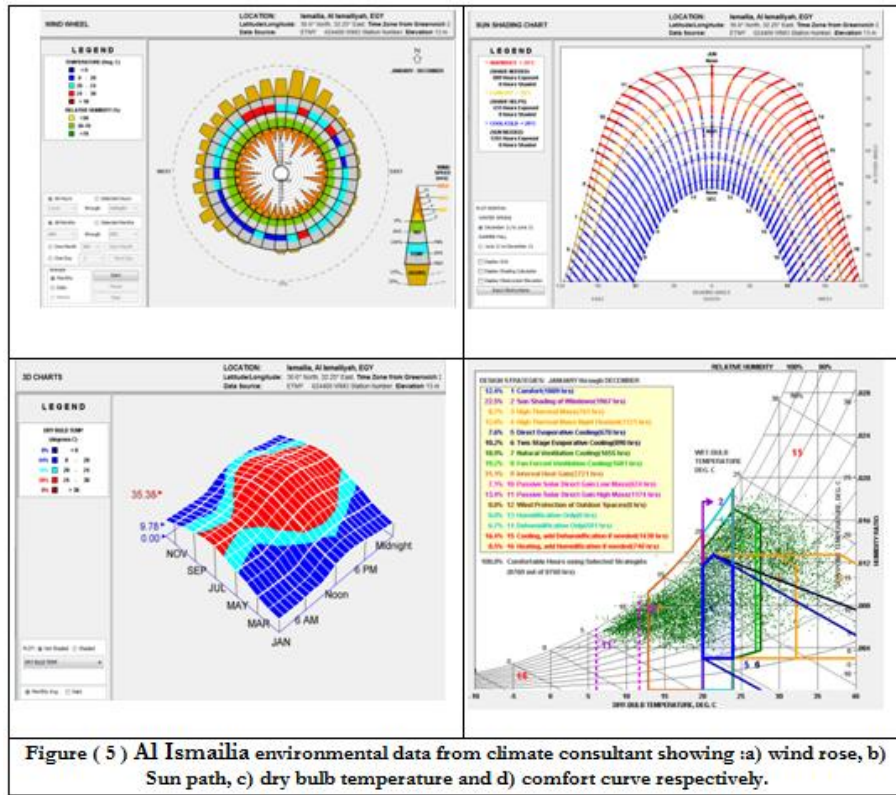


Figure ( 5 ) Al Ismailia environmental data from climate consultant showing :a) wind rose, b) Sun path, c) dry bulb temperature and d) comfort curve respectively.

#### 4.2.2 Developing Form according to environment

As a result of the previous environmental parameters the form accomplished by theories for used spaces from the program were adapted in shape to cope with the surrounding environment, Fig. (6).

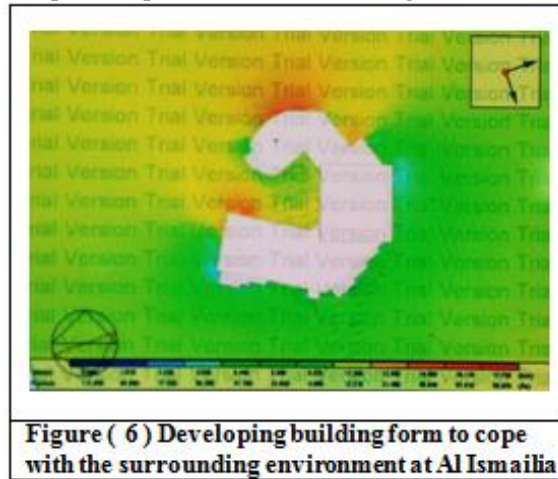
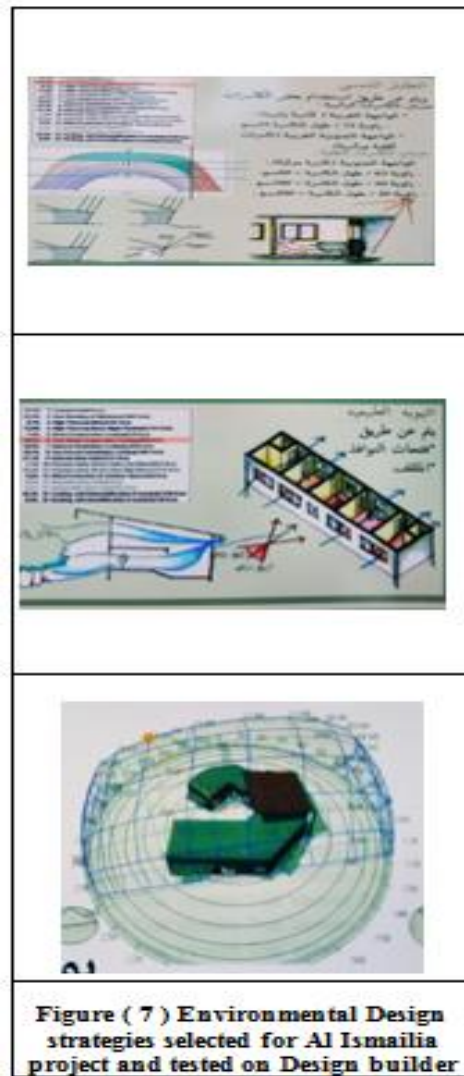


Figure ( 6 ) Developing building form to cope with the surrounding environment at Al Ismailia

#### 4.2.2 Developing Form according to environment

As a result of the previous environmental parameters the form accomplished by theories for used spaces from the program was adapted in shape to cope with the surrounding environment, Fig. (6).





#### 4.2.3 Environmental design strategies

- Use of the solar breakers for windows according to solar path to allow needed rays for getting thermal comfort and preventing unwanted solar rays. Also students are required to test these breakers to figure out whether they succeeded in preventing undesired solar rays and allowing desired rays in order to deliver thermal comfort and natural light inside the building as shown in student presentation, , figure (7) .
- Students consider building depth and location, operation of openings in external walls to optimize natural ventilation.
- Also wind catchers were used in order to direct airflow downward using direct wind entry, , figure (7) .
- When natural ventilation alone is not suitable, exhaust fans (with adequate pre-testing and planning) can be installed to increase ventilation rates in rooms housing. The fans should be installed where room air can be exhausted directly to the outdoor environment through either a wall or the roof, figure (7).
- Using Double walls to enhance thermal performance of the building envelope and isolate heat internally.
- Shading accomplished either by plants and trees or changing floors level rise helps in the reduction of exteriors walls temperature, figure (1).

#### 4.2.4 Students' presentation

Students presented their project, figure (8), on printed colored banners and a jury was carried to verify their complete understanding of the design process according to environmental parameters.

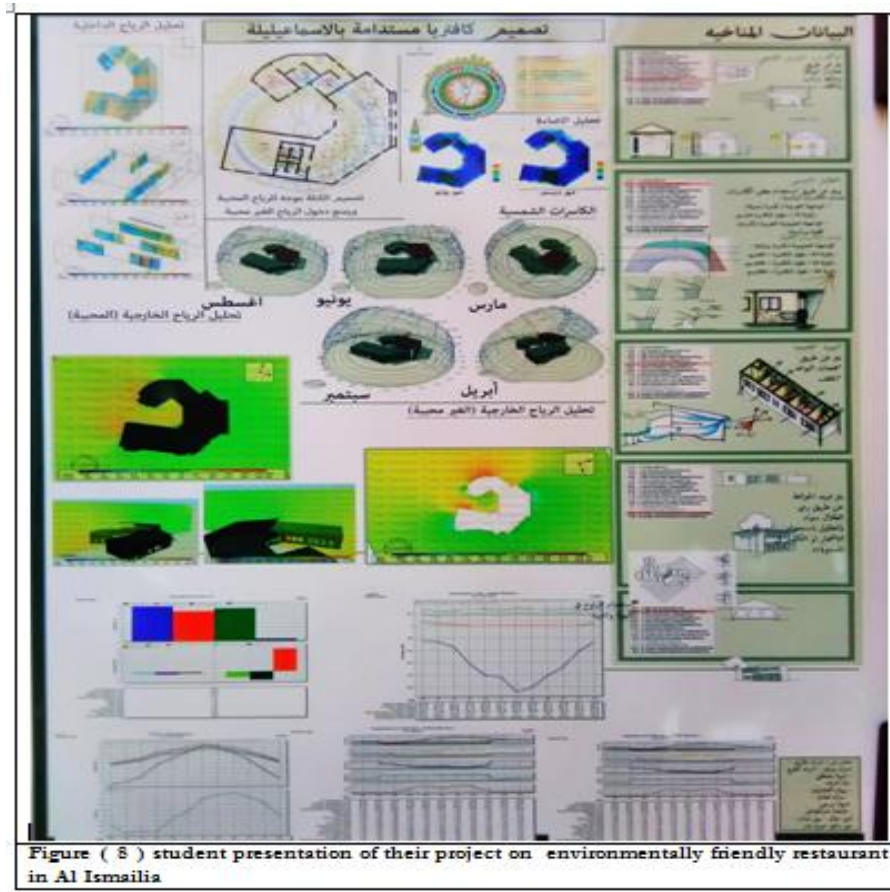


Figure ( 8 ) student presentation of their project on environmentally friendly restaurant in Al Ismailia

### 4. 3 Third Project:

Designing an environmental friendly restaurant in Al Kharga, Alwadi El-jadid ,Egypt.

#### 4.3.1 Environmental data:

- Wind rose at Al Kharga:

It is clear from the wind rose, figure (9), at the selected site of the third project at kharga during the year, that the undesirable prevailing winds are from north west with a temperature of 38 to 24 degrees Celsius. It is the longest period of wind blowing, so students have to avoid these unwanted winds and disperse them. Also, they had to change their building form accordingly.

- Sun Path at Al Kharga:

The solar path, figure (9), shows that the solar radiation with a high angle over 50 is undesirable hot and the vertical radiation on the eastern façade. Also, the radiation on the southern façade at an angle of less than 50 degrees is desirable. Therefore, the solar breakers had to be designed to allow the desired rays to reach Building and preventing unwanted rays.

- Dry bulb temperature at Al Kharga:

The three-dimensional curve of the temperature of the dry thermometer, figure (9), shows that the temperature in the months of May, September, June, and July is high and undesirable. They must be avoided and treated especially in the afternoons of July and September. The curve shows also temperatures throughout the day.

• Comfort Curve at Al Kharga:

The thermal comfort curve, figure (9), shows the number of comfortable hours and design policies proposed to dissipate thermal comfort for the rest of the time and recommendations were as follow:

- Using suitable solar breakers for windows modify 2504 uncomfortable hours to comfortable hours.
- Indirect cooling of the radiation change uncomfortable 3204 hours to comfortable hours.
- Direct evaporative cooling change 2295 uncomfortable hours to convenient hours.
- Keeping the stability of the internal temperature of the room can modify 1826 uncomfortable hours to comfortable hours

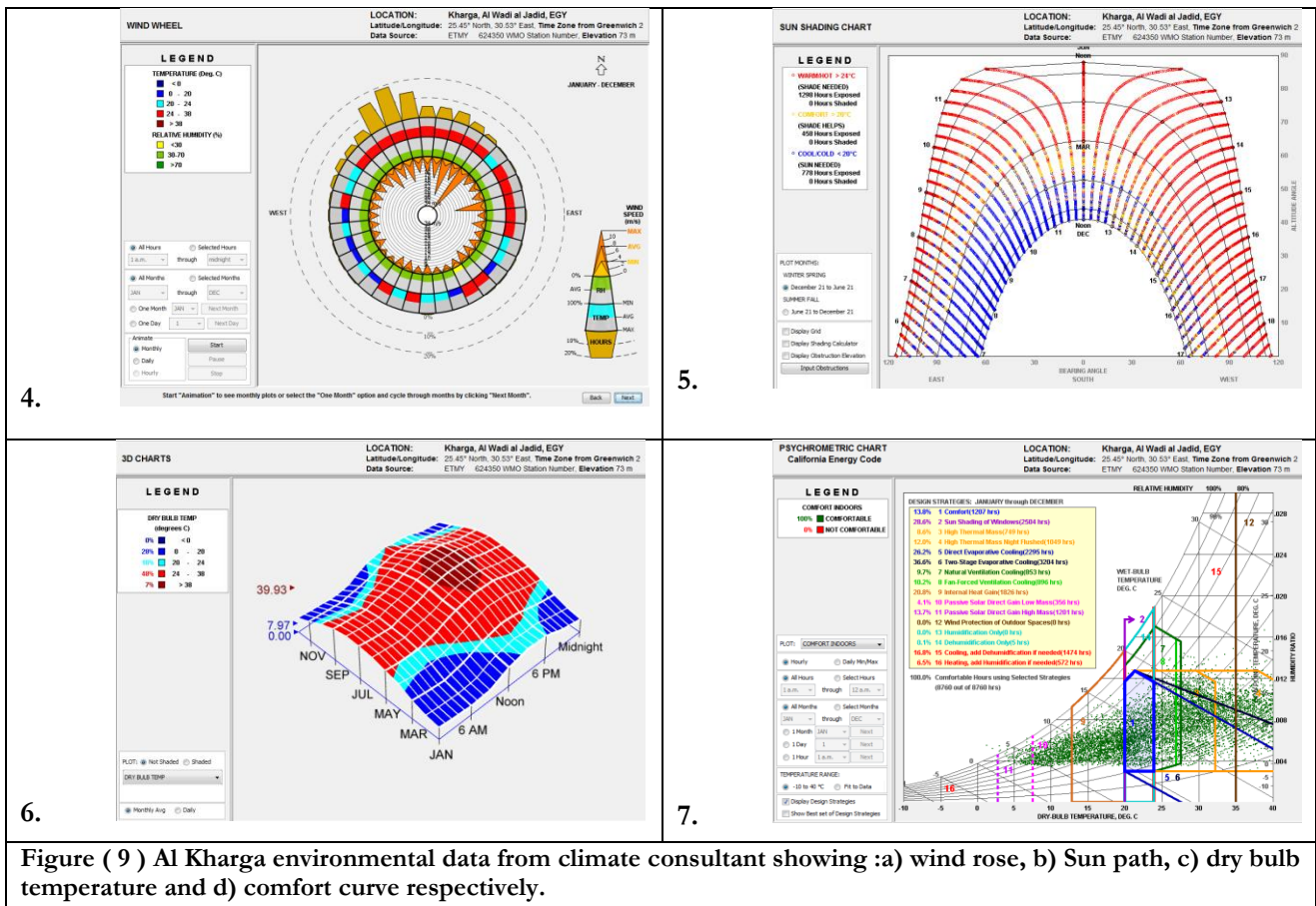


Figure (9) Al Kharga environmental data from climate consultant showing :a) wind rose, b) Sun path, c) dry bulb temperature and d) comfort curve respectively.

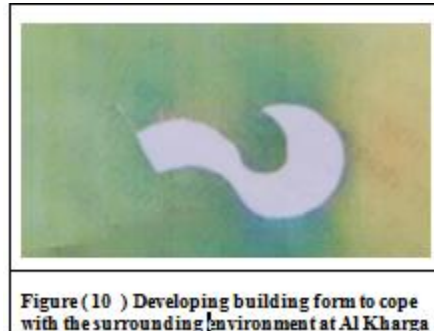


Figure (10) Developing building form to cope with the surrounding environment at Al Kharga

4.3.2 Developing Form according to environment

As a result of the previous environmental parameters the form accomplished by theories for used spaces from the program were adapted in shape to cope with the surrounding environment,, figure (10).

#### 4.3.3 Environmental design strategies

- Students consider building form and increase of external wall thickness to enhance thermal performance of the building envelope and isolate heat internally.
- Use of the solar breakers for windows according to solar path to allow needed rays for getting thermal comfort and preventing unwanted solar rays. Sun breakers are used also as shading for windows, **figure (11)**.
- Direct evaporating cooling so student used water drops to evaporate.
- Students used evaporative cooling of air to add benefit of conditioning the air with more moisture for the comfort of building occupants.
- Also Double roof was used to minimize solar gain and heat storage. Also, to provide under roof ventilation and environmental shading, **figure (11)**.
- Internal heat gain students reduced filtration as possible as can to obtain heat in space with double walls to isolate heat.
- When natural ventilation alone is not suitable, exhaust fans (with adequate pre-testing and planning) can be installed to increase ventilation rates in rooms housing. The fans should be installed where room air can be exhausted directly to the outdoor environment through either a wall or the roof, **figure (11)**.

#### 4.3.4 Students' presentation

Students presented their project, figure (12), on printed colored banners and a jury was carried to verify their complete understanding of the design process according to environmental parameters.

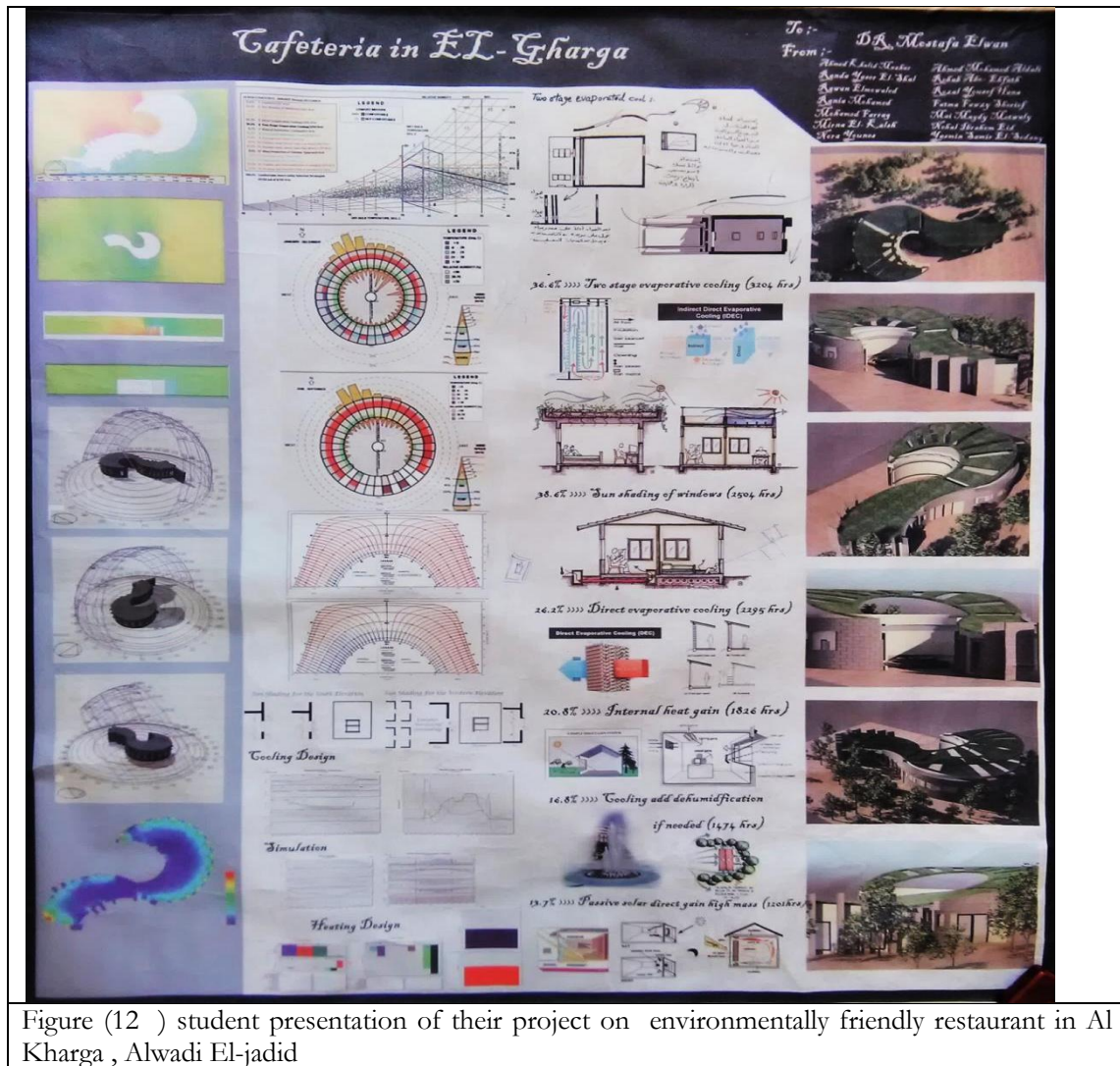


Figure (12 ) student presentation of their project on environmentally friendly restaurant in Al Kharga , Alwadi El-jadid

## 5. Discussions

The design studio is the nucleus of architecture program and practice. The entire architecture program terminates in the design studio. The architect-educator is expected to impart the students with the skills that will enable them to be competent in architecture and its practice.<sup>9</sup> The aim of this studio work was to introduce students to design approach through environmental thinking. The task of the student was to use knowledge and skills gained in the course to transform design ideas into plan and form ruled by surrounding environmental parameters. Also it is a systematic way of design development to achieve rational creative design solutions.

Even though teachers had similar bias and insisted on environmental aspects of the building design, the problems encountered by the students were similar, and the final projects showed a homogeneously wide spectrum designs for each group. The different experiences the students had on different sites during the first phase of the studio were the base of their arguments in the design strategic choices for their buildings in the second phase. However, the locations of building were chosen according to their perception of ambiances in each site. This course forced students to become conscious of their gained experience to take the right design decisions. Also, the process of gathering their work stages into words and presentation reinforced the unconscious learning process they went through. Indeed, the presentations showed that students were well aware of the stages they had encountered, and that they were able to express them often very clearly, as shown in previous presentations figures.

<sup>9</sup> Olotuah, A. O., Taiwo, A. A., & Ijatuyi, O. O. (2016). Pedagogy in Architectural Design Studio and Sustainable Architecture in Nigeria. *Journal of Educational and Social Research*, 6(2), 157.

In the following, we will summarize some of the issues observed during the course:

- The analysis of the large scale (the site), the integration of the different scales (theories and weather data), contributes to an association between “nature” and built project architecture, where “nature” becomes not only a view framed by the project but the threads of the design process.
- The issue of the perception and analysis of the site led many students to face many questions of any design thinking process.
- Most students seemed to have appreciated working in group. It allowed them to confront and enrich their ideas of their own way of feeling and thinking, and to understand different ways of seeing and understanding the site.
- The limit of a studio course, on short school semester, makes us discuss having it in a longer timeframe. Students regretted not having enough time to deepen the study of the site by talking to the inhabitants, to involve them in the project; to live the site and to see it change; to understand it with those who actually use it.

## 6. Conclusions

Architecture schools are the occasion to explore different ways of creating an architect. Within the necessarily limited time-frame of architectural training, students knew the site throughout all seasons and weather, and where they could act not as much as designers of objects, but as designers of process. Such a design process can achieve the ideal sustainable environmental design. While they recognize knowledge and tools to cope with the surrounding environment, they rationally take their design decisions. The design thinking process is a key issue in this study. No disagreement seems to exist among most educators and studio instructors regarding the importance of environmental thinking in improving learning and teaching practices in the studio. The quality of the human environment is the principal concern in architecture. Thus architectural education must strive to train professionals who would understand the nature of the human problem in its environmental context and possess the intellectual and aesthetic skills to create relevant and expressive design solutions. The course described here already offers a rather engaged way of dealing with these issues in an architecture school. Remarks on the students output in the course are an invitation to go even further. In this strategy, teaching and learning environment in design studios in architectural education would foster students' creativity and strengthen their interest, motivation and commitment to achieve and maintain sustainable human environment.

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